24(2), 24(7)

AUTHOR: Mashkevich, V. S. SOV/48-22-11-6/33

TITLE: The Method of Quasi-Normal Coordinates in the Optics of Crystals (Metod kvazinormal'nykh koordinat v optike kristallov)

PERIODICAL: Izvestiya Akademii nauk SSSR. Seriya fizicheskaya, 1958, Vol 22, Nr 11, pp 1308 - 1311(USSR)

ABSTRACT: The present paper deals with the general principles of the method of quasi-normal coordinates and its application to ion crystals with a space lattice of the NaCl type. At present, 2 approximations are being used in the theory of crystal lattice vibration: approximation of point atoms (ions) (Ref 4), and of dipoles (Refs 3,5). In the point approximation the state of the crystalline particles is described by means of their shifting u_s^{ℓ} (ℓ - number of the elementary cell, s - number of the particle contained therein). In the more accurate dipole-approximation the dipole-moments are considered in addition to the above mentioned variables. These dipole-

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The Method of Quasi-Normal Coordinates in the Optics of Crystals SOV/48-22-11-6/33

moments are caused by the deformation of the electron shell. This method is based on the idea of selecting the coefficients $c_{\alpha\beta}$ in such a way that the coordinates Q^{α} thus obtained describe both the light waves and the vibrations of other than of luminous character. In this case H', which already furnishes the relation of individual Q-vibrations in harmonic approximation, will describe the single-phonon light absorption in qualitative harmony with the results of the forced oscillations method. A concrete selection of $c_{\alpha\beta}$ naturally depends on the type of crystal. It can, however, also be done in accordance with some general requirements resulting from the observation of the inner electric field. In the case of an ion crystal, when taking into account of the polarization of the particles results only in quantitative corrections, but does not influence the qualitative character of the spectrum (Refs 3,5). The vibration spectrum consists of 8 branches: 3 acoustic, 1 longitudinal, and 4 transverse optical branches. Of these the transverse optical branches are important in

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connection with the spreading of light. In the case of an ion crystal, H' differs from zero already in the zero-th approximation of k. In the above mentioned approximation, frequencies relating to 2 different polarizations are in agreement. Accordingly, all results agree. Zero solutions are not to be taken into account. They result in normal initial vibrations so that:

$$\frac{c_{11}D}{n_1^2(n_2^2 - 1)} - \frac{c_{21}}{n_2^2(n_1^2 - 1)} = 0. \qquad (22)$$

(22) and (6) $\sum_{\beta} |c_{\beta\alpha}(\vec{k})|^2 = 1$, determine c_{11} and c_{21}, so that, in principle, the introduction of quasi-normal coordinates is completed. There are 5 references, 4 of which are Soviet.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnical Institute)

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AUTHOR: Mashkevich, V. S. SOV/20-121-2-14/53

TITLE: The Normal Coordinates of a Crystal Lattice With Allowance For Interaction Lag (Normal'nyye koordinaty kristallicheskoy reshetki pri uchete zapazdyvaniya vzaimodeystviya)

PERIODICAL: Doklady Akademii nauk SSSR, 1958, Vol. 121, Nr 2, pp. 247 - 249 (USSR)

ABSTRACT: For the theoretical investigation of a number of properties of crystals it becomes necessary to introduce normal coordinates. An elementary solution of this problem can be found for purely mechanical oscillations without consideration of the interaction lag. In the following the author demonstrates the introduction of normal coordinates in the general case for a crystal lattice in dipole approximation. Starting from the equation of motion (disregarding the inertia of the dipole moments) and the expressions for $\vec{u}_s^l$ and $\vec{p}_s^l$, the author sets up the amplitude equation (for plane monochromatic waves); furthermore the equations for

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$\vec{\mathcal{E}}_s^{\,l}$ as well as for $\vec{\mathcal{E}}(r,t)$, $\vec{\mathcal{E}}$, $\vec{\mathcal{B}}$, and $\vec{A}$ are given as functions of $q^\alpha(\vec{k},t)$. The expression $E = \sum_{\alpha}' \left[\dot{q}^\alpha(\vec{k})\,\dot{q}^{*\alpha}(\vec{k}) + \omega_\alpha^2(\vec{k})\,q^\alpha(\vec{k})\,q^{*\alpha}(\vec{k})\right]$ is obtained for the energy of the lattice. The equation of motion is $\ddot{q}^\alpha(\vec{k}) + \omega_\alpha^2(\vec{k})q^\alpha(\vec{k}) = 0$ with $p^\alpha(\vec{k}) = \dot{q}^{*\alpha}(\vec{k})$ and $p^{*\alpha}(\vec{k}) = \dot{q}^\alpha(\vec{k})$. Expressions for L and H are also given. The denotation is the usual one ; $\vec{u}_s^{\,l}$ -atom displacement, $\vec{p}_s^{\,l}$ - the dipole moment caused by the deformation of the electron shell; the index l serves for numbering the unit cells, and s for the atoms or ions, respectively; $\vec{\mathcal{E}}_s^{\,l}$ electric field intensity in the lattice point with the coordinates $\vec{r}_s^{\,l}$. The asterisk denotes the conjugated complex quantities which are obtained by replacing $\vec{k}$ by $(-\vec{k})$. Thus for example there holds $q^\alpha(-\vec{k}) = q^{*\alpha}(\vec{k})$. There are 3 references, 1 of which is Soviet.

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ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnical Institute)

PRESENTED: April 8, 1958, by N.N.Bogolyubov, Member, Academy of Sciences, USSR

SUBMITTED: April 7, 1958

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24(2)
AUTHOR: Mashkevich, V. S. SOV/56-36-1-16/62

TITLE: The Electrical, Optical, and Elastic Properties of the Crystals of the Type of a Diamond (Elektricheskiye, opticheskiye i uprugiye svoystva kristallov tipa almaza) III. Dispersion and Absorption of Light (III. Dispersiya i pogloshcheniye sveta)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 1, pp 108-115 (USSR)

ABSTRACT: The author develops a quantitative theory for the lattice vibrations of a homeopolar crystal. Four parts of the present paper deal with dispersion and double refraction far from the singular point, with the quasinormal coordinates, with dispersion and double refraction in the neighborhood of the singular point, and with the absorption of light. In the fifth part, the parameters of the theory and the numerical results are given. The following conclusions can be drawn from the considerations discussed in the present paper:
1) The theory confirms the presence of dispersion and double refraction, which are caused by the vibrations of the atoms in the crystal. Both effects have their maximum intensity

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The Electrical, Optical, and Elastic Properties of the Crystals of the Type of a Diamond. III. Dispersion and Absorption of Light SOV/56-36-1-16/62

in the neighbourhood of the extreme frequency of the optical vibrations where the difference of the refraction indices for the 2 polarizations amounts to 10^{-4}. 2) A crystal of the diamond type has 7 axes, and the directions of the optic axes coincide with the directions of the edges and diagonals of the lattice cube. The theory asserts a one-phonon absorption of light with the extreme frequency of the optic vibrations and further gives the dependence absorption on the propagation direction and on the polariza of light. 4) An experimental verification of these results of the theory would be very advantageous, for it would permi comparison with experimental results of that part of the theory which concerns the optical properties. There are 1 table and 8 references, 6 of which are Soviet.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: May 16, 1958

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24(2)

AUTHOR: Mashkevich, V. S.

SOV/56-36-6-17/66

TITLE: Electrical, Optical, and Elastic Properties of Crystals of the Diamond Type (Elektricheskiye, opticheskiye i uprugiye svoystva kristallov tipa almaza). IV. Interaction Between the Conductivity Electron and Lattice Vibrations (IV. Vzaimodeystviye elektrona provodimosti s kolebaniyami reshetki)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 6, pp 1736 - 1742 (USSR)

ABSTRACT: The interaction between an electron and the lattice vibrations of an ion crystal may be dealt with already in point ion approximation if the polarization connected with the vibrations is taken into account. In the case of a homeopolar crystal no polarization occurs in this approximation. This makes it possible to operate either with Bloch- or with deformation potentials. The author of the present paper, by taking the atomic dipole moments into account, develops a quantitative theory of interaction between electron and lattice vibrations, and, by using this theory, investigates the problem of the existence of polarons in homeopolar crystals

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Electrical, Optical, and Elastic Properties of Crystals SOV/56-36-6-17/66
of the Diamond Type. IV. Interaction Between the Conductivity Electron
and Lattice Vibrations

and calculates the mobility of the conductivity electron. For the purpose of simplifying calculations, the complexity of isoenergetic surfaces in the conductivity zone is not taken into account and the simplest model of spherically symmetric surfaces with the center at point $\vec{K} = 0$ is used. With respect to the problem of the existence of large radius polarons the author arrives at the same conclusion as Deygen and Pekar, namely that the zonal state of the electron is stable (or metastable) and that polarons with a large radius do not exist. The interaction between electron and lattice vibrations is investigated by means of the perturbation theory. The results concerning electron mobility and its temperature dependence are compared with the experimental results obtained by other authors, viz. for diamonds (Table 1) and germanium (Table 2). Table 3 shows the experimentally determined electron mobility at 300°K and the effective masses for diamonds, silicon, and germanium calculated herefrom by means of the equation (22) of this paper. A comparison with the experiments shows that the theory leads to satisfactory results. The

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of the Diamond Type. IV. Interaction Between the Conductivity Electron
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author finally thanks K. B. Tolpygo for discussing the results obtained. There are 3 tables and 16 references, 7 of which are Soviet.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: December 4, 1958

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S/139/60/000/004/026/033
E032/E514

AUTHOR: Mashkevich, V.S.

TITLE: Higher Approximations in Equations Describing the State of Matter in Electrodynamics

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, 1960, No.4, pp. 217-221

TEXT: The electrical and magnetic state of matter is usually described by the polarization and magnetization vectors P and I, assuming that the relation between these vectors and the displacement and magnetic induction is:

$$\underline{D} = \underline{E} + 4\pi \underline{P} \qquad (1)$$

$$\underline{B} = \underline{H} + 4\pi \underline{I} \qquad (2)$$

The equations describing the electromagnetic state of matter are then established by deducing the polarization and magnetization as a function of the fields E and H. When the wavelength of the electromagnetic wave λ is large compared with molecular dimensions d, the fields can be expanded in powers of d/λ. In

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many cases the zero-order approximation is insufficient. For example, in calculations concerned with optical activity, first-order terms must be included (Born, Ref.1) while optical anisotropy of cubic crystals requires the introduction of second-order terms also (Tolpygo and Mashkevich, Ref.2). The present paper is concerned with these higher-order approximations. Formulae are derived for the macroscopic vectors, in terms of microscopic quantities. The treatment is entirely classical. There are 2 Soviet references.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnical Institute)

SUBMITTED: May 20, 1959

MASHKEVICH, V.S.

Higher approximations in the Ewald method. Fiz. tver. tela 2 no.5:908-912 My '60. (MIRA 13:10)

1. Politekhnicheskiy institut, Kiyev.
(Lattice theory)

84617

S/181/60/002/010/045/051
B019/B056

24.7500 (1043,1145,1160)

AUTHOR: **Mashkevich, V. S.**

TITLE: Dipole Approximation in the Micro-theory of Crystals. I. Lattice Vibrations Taking in Consideration the Electron Dispersion

PERIODICAL: Fizika tverdogo tela, 1960, Vol. 2, No. 10, pp. 2629 - 2636

TEXT: K. B. Tolpygo, in the Born theory of the crystal lattice improved by him, proceeded from the assumption that the potential energy of the crystal depends on the displacement and the electron dipole moments of ions. At the same time, he neglected the inertia of the electron dipole moments or of electron dispersion. In the present paper the electron dispersion for lattice vibrations, the frequency of which is small compared to that of the electron transitions, is taken into account. Besides, "sub-cells" are assumed to be crystal elements, which are considered to be parts of the unit cells belonging to the nuclei. In the first part, the Hamiltonian of the electron system is set up in harmonic

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Dipole Approximation in the Micro-theory of Crystals. I. Lattice Vibrations Taking in Consideration the Electron Dispersion

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approximation, after which the delayed interaction of the lattice vibrations with the electromagnetic field characterised by the vector potential $\vec{A}$ is investigated. For the perturbation operator $\hat{H}'$ in the Hamiltonian of the system the expression $\hat{H}' = \hat{h}^{(+)}\exp(-i\omega t) + \hat{h}^{(-)}\exp(i\omega t)$ (9) is obtained. With the aid of (9) for the wave function the expression $\psi' = v^{(+)}\exp\left[-i(\omega_o + \omega)t\right] + v^{(-)}\exp\left[-i(\omega_o - \omega)t\right]$ (11) is obtained, where $v^{(\pm)} = \sum_n (n|h^{(\pm)}|0)\psi_n/\hbar(\omega_o - \omega_n \pm \omega)$. Moreover, from the "equations of motion" of the electron dipole moments and the equation of motion of the centers of mass of the "sub-cells", the amplitude equations are derived. Finally, several properties of the coefficients of the two amplitude equations are discussed. The results given here represent a generalization of the theory developed by Tolpygo in the following respects: 1) No assumptions are made about the existence of the potential energy. 2) The electron dispersion is taken into account. 3) The difference

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Dipole Approximation in the Micro-theory of Crystals. I. Lattice Vibrations Taking in Consideration the Electron Dispersion

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between the nucleus coordinate and the coordinates of the centers of mass are taken into account. 4) A zero dipole moment is assumed. 5) No assumptions are made as to the binding of the electrons in the ions and the approximationsof the wave functions. In a following paper, vibrations of dipole moments with frequencies lying within the range of electron transitions are to be investigated. The author thanks K. B. Tolpygo for discussion of the results obtained. There are 7 references: 6 Soviet and 1 German.

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ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: March 14, 1960

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B006/B014

9.3700

AUTHOR: Mashkevich, V. S.

TITLE: Electromagnetic Waves in a Medium With a Continuous Energy Spectrum.

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 3, pp. 906-911

TEXT: In the case of spatial dispersion it is possible to consider polarisability to be a factor of proportionality between polarization vector and field strength. The effect of spatial dispersion was studied by Pekar (Ref. 1) for the exciton state. In the article under review, the author studies certain currentless states and approaches the dependence of the polarisation vector on the field strength by using the perturbation theory. He uses a modification of the Weisskopf-Wigner method similar to that employed by Born et al. (Ref. 2). The Hamiltonian of this system is set up as the sum of the unperturbed Hamiltonian $\hat{H}^0$ of the dissipative perturbation $\hat{H}'_d$ and the electromagnetic perturbation $\hat{H}'$. The wave function

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of the system is similarly composed. $\hat{H}_d'$ is determined from the interaction between electrons and lattice vibrations. It is assumed that when t=0 the system is in the ground state, and that the interferences of energy dissipation of the various states and the width of the ground state are negligible. $\hat{H}' = \hat{h}^{(+)}\exp(-i\omega t) + \hat{h}^{(-)}\exp(i\omega t)$, and the corresponding steady-state solution of the wave function Ψ' can be written down. Next, the author studies the dependence of polarization on the electric field, and derives a number of relations. In conclusion, he studies the dispersion relations for the so-called kernel of polarizability, and discusses the solutions of the Maxwell equations. There are 4 Soviet references.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: September 3, 1959

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BAKRADZE, R.V.; MASHKEVICH, V.S.

P-approximation in the theory of a diamond-type crystal lattice. Izv. vys.ucheb.zav.; fiz. no.1:35-40 '61. (MIRA 14:7)

1. Kiyevskiy politekhnicheskiy institut.
(Dipole moments) (Crystal lattices)

25200

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[illegible]700(1482, 1163)

AUTHOR: Mashkevich, V. S.

TITLE: Electromagnetic waves in a medium with a continuous energy spectrum. II

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1803 - 1811

TEXT: In a previous paper (Ref. 1: ZhETF, 38, 906, 1960), the author has derived equations for a electromagnetic field in a non-conducting medium with spatial dispersion. The results are now applied to exciton states of a crystal. Calculations are made on the basis of the integro-differential equation

$$\Delta \mathcal{E}^{\perp}_{x}(\mathbf{r}) + \gamma \mathcal{E}^{\perp}_{x}(\mathbf{r}) + 4\pi\gamma \int K^{\perp}_{xx'}(\mathbf{r}, \mathbf{r}') \mathcal{E}^{\perp}_{x'}(\mathbf{r}')\, d\mathbf{r}' = 0, \qquad (1)$$

$$\mathcal{E}^{\parallel}_{x}(\mathbf{r}) = -4\pi \int K^{\parallel}_{xx'}(\mathbf{r}, \mathbf{r}') \mathcal{E}^{\perp}_{x'}(\mathbf{r}')\, d\mathbf{r}', \qquad (2)$$

which automatically accounts for the additional conditions and requires only

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the selection of the exciton wave functions; as the latter, the author used those of S. I. Pekar (Refs. 2,3: ZhETF, 33, 1022, 1957; ZhETF, 34, 1176, 1958). In Eq. (1), $\gamma = \mu\omega^2/c^2$; the polarizability kernel is given by

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$$K_{x'y'}(\mathbf{r}, \mathbf{r}') = K^{\perp}_{x'y'}(\mathbf{r}, \mathbf{r}') + K^{\parallel}_{x'y'}(\mathbf{r}, \mathbf{r}') = \frac{1}{\hbar\omega}\sum_n (E_n - E_0)\left[\frac{(0|O_{x'}(\mathbf{r})|n)(n|O_{y'}(\mathbf{r}')|0)}{E_n - E_0 - \hbar\omega - i\varepsilon_n(\omega)} - \frac{(n|O_{x'}(\mathbf{r})|0)(0|O_{y'}(\mathbf{r}')|n)}{E_n - E_0 + \hbar\omega + i\varepsilon_n(-\omega)}\right]. \tag{3}$$

$$\mathrm{div}_r K^{\perp}_{y'}(\mathbf{r}, \mathbf{r}') = 0, \quad \mathrm{rot}_r K^{\parallel}_{y'}(\mathbf{r}, \mathbf{r}') = 0. \tag{4}$$

where E_0 is the ground-state energy and E_n that of the excited state; ε_n is related to the lifetime of the state as usual; $\vec{O}(\vec{r})$ is the operator of the electric moment per unit volume; the operator "rot" indicates "curl". For waves in an infinite crystal, Eq. (3) is transformed into

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$$K_{x'y'}(\mathbf{r}, \mathbf{r}') = K^{+}_{x'y'}(\mathbf{r}, \mathbf{r}') + K^{-}_{x'y'}(\mathbf{r}, \mathbf{r}'), \tag{5}$$

$$K^{\pm}_{x'y'}(\mathbf{r}, \mathbf{r}') = \frac{L^{3}}{(2\pi)^{3}\hbar\omega} \sum_{\alpha} \int \Gamma^{\pm}(\mathbf{k}, \alpha) \times$$

$$\times \sum_{\mathbf{b}\mathbf{b}'} g^{\pm}_{x'y'}(\mathbf{b}, \mathbf{b}', \mathbf{k}, \mathbf{k}, \alpha) \exp[\mp i\mathbf{k}(\mathbf{r} - \mathbf{r}') \mp i2\pi(\mathbf{b}\mathbf{r} - \mathbf{b}'\mathbf{r}')]\, d\mathbf{k}; \tag{6}$$

$$\Gamma^{\pm}(\mathbf{k}, \alpha) = \mp \frac{E(\mathbf{k}, \alpha) - E_0}{E(\mathbf{k}, \alpha) \pm i\varepsilon'(\mathbf{k}, \alpha, \mp\omega) - E_0 \pm \hbar\omega},$$

$$g^{+}_{x'y'}(\mathbf{b}, \mathbf{b}', \mathbf{k}, \mathbf{k}', \alpha) = g^{*}_{x'}(\mathbf{b}, \mathbf{k}, \alpha)\, g_{y'}(\mathbf{b}', \mathbf{k}', \alpha), \quad g^{-} = g^{+*},$$

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with the exciton quasi-momentum $\vec{k}$ and the vector $\vec{b}$ of the reciprocal lattice. Taking into account that the generatrix of $\vec{k}$ in (6) cannot be analytic at the point $\vec{k} = 0$, one may rewrite Eq. (1) in the form

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$$\Delta\mathcal{E}_{x'}^{\perp}(\mathbf{r}) + \gamma\beta_{x'y'}^{\perp}\mathcal{E}_{y'}^{\perp}(\mathbf{r}) + 4\pi\gamma\int\chi_{x'y'}^{\perp}(\mathbf{r},\mathbf{r}')\,\mathcal{E}_{y'}^{\perp}(\mathbf{r}')\,d\mathbf{r}' = 0, \tag{7}$$

$$\beta_{x'y'}^{\perp} = \delta_{x'y'} + \frac{4\pi L^{2}}{\hbar\omega}\Big[\sum_{a}\Gamma^{+}\Big(-al\frac{\partial}{\partial\mathbf{r}},\alpha\Big)g_{x'y'}^{+\perp}\Big(0,0,\Big(-al\frac{\partial}{\partial\mathbf{r}}\Big)^{*}-al\frac{\partial}{\partial\mathbf{r}},\alpha\Big)+$$
$$+\sum_{a}{}'\,\Gamma^{-}\Big(-al\frac{\partial}{\partial\mathbf{r}},\alpha\Big)g_{x'y'}^{-\perp}\Big(0,0,-al\frac{\partial}{\partial\mathbf{r}},\Big(-al\frac{\partial}{\partial\mathbf{r}}\Big)^{*},a\Big)\Big]_{a=+0}. \tag{8}$$

The primed sum in (8) indicates that terms containing a singularity are neglected. The wave function $\Phi_{\alpha\vec{k}} = 2^{-1/2}(\psi_{\alpha\vec{k}} - \psi_{\alpha\tilde{\vec{k}}})$ is used for the case of a wave passing through a plane-parallel plate of a cubic crystal. $\psi_{\vec{k}_0}$ is the wave function of the infinite crystal.

$\widetilde{\vec{k}\vec{a}}_{1,2} = \vec{k}\vec{a}_{1,2} \equiv k_{1,2}$; $-\widetilde{\vec{k}\vec{a}}_{3} = \vec{k}\vec{a}_{3} \equiv k_{3} = \pi\nu/(N+1)$,

$\nu = 1,\dots,N$; $\vec{a}_{1,2}$ are the parallel surfaces of the plate, N the number of

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unit cells across the thickness 1 of the plate. When the z-axis is perpendicular to the surfaces of the plate, the integral kernel has the form

$$K^{\pm}_{x'y'}(\mathbf{r},\mathbf{r}') = \frac{L^2}{(2\pi)^2\,2\hbar\omega}\sum_{\alpha}\sum_{k_z=-k_N}^{k_N}\int\Gamma^{\pm}(\mathbf{k},\alpha)\sum_{\mathbf{b}\mathbf{b}'}\exp\left(\mp i\,[k_3b_{3z}z + \right.$$

$$+ k_x(x-x') + k_y(y-y') + (k_1b_{1z}+k_2b_{2z})(z-z') + 2\pi(\mathbf{br}-\mathbf{b}'\mathbf{r}')]\Big)\times$$

$$\times\,[g^{\pm}_{x'y'}(\mathbf{b},\mathbf{b}',\mathbf{k},\mathbf{k},\alpha)\exp(\pm ik_3b_{3z}z') -$$

$$- g^{\pm}_{x'y'}(\mathbf{b},\mathbf{b}',\mathbf{k},\tilde{\mathbf{k}},\alpha)\exp(\mp ik_3b_{3z}z')]\,dk_x\,dk_y. \qquad (13)$$

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where $k_N = \pi N/(N+1)$. In this case, the equation of the field is given by

$$\frac{d^2\mathcal{E}(z)}{dz^2} + \eta\,\mathcal{E}(z) + \frac{\rho}{2l}\sum_{\alpha}{}'\sum_{bb'}\int_0^l\chi(z,z',b,b',\alpha)\,\mathcal{E}(z')\,dz' = 0. \qquad (14)$$

provided $\mathcal{E}(z)$ lies in the y-direction. The sum over α concerns transverse excitons only, $b = nb_{3z}$ (n = integer number), $\eta = \gamma\beta$, $\rho = 4\pi\gamma L^2 l/\hbar\omega$;

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$$\chi(z, z', b, b', \alpha) = \exp[i2\pi(bz - b'z')] \sum_{k=-k_N}^{k_N} \Gamma_0^-(k, \alpha)\, g_0(b, k, \alpha) \times$$
$$\times \exp(ikz)\,[g_0^*(b', k, \alpha)\exp(-ikz') - g_0^*(b', -k, \alpha)\exp(ikz')], \quad (15)$$

where $f_0(b,k) = f(n\vec{b}_3, \vec{k})\big|_{k_{x,y}=0}$, $f = \Gamma, g$. The solution of Eq. (14) has the form

$$\mathscr{g}(z) = \sum_s c_s \exp(i\varkappa_s z), \quad (16)$$

where $\varkappa_s$ are the roots of the equation

$$-\varkappa^2 + \eta + ?\sum_a'' g_0^-(0, 0, \varkappa, \varkappa^*, \alpha)\,\Gamma_0^-(\varkappa, \alpha) = 0. \quad (17)$$

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Electromagnetic waves in a ...

Finally, the absorption of an electromagnetic wave with spatial dispersion is investigated, leading to the term

$$\overline{W} = -2i\omega \int R_{x'y'}(\mathbf{r}, \mathbf{r}')\, \mathcal{E}^{+*}_{x'}(\mathbf{r})\, \mathcal{E}^{+}_{y'}(\mathbf{r}')\, d\mathbf{r}\, d\mathbf{r}'.$$

where $R_{x'y'}$ is the anti-Hermitean part of the kernel $K_{x'y'}$. There are 7 Soviet-bloc references.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: January 11, 1961

BROUDE, V. A., MASHKEVICH, V. S., PRIKHOT'KO, A. F., PROKOPYUK, N. F. , SOSKIN, M. S.

"Induced radiation in molecular crystals."

A four-level scheme for a quantum generator was discussed. It was shown that optical properties of molecular crystals provide a basis for the realization of a quantum generator.

The report presented to the 11th Conference on Luminescence (Molecular luminescence and luminescence analysis) Minsk, 10-15 Sept. 1962.

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S/181/62/004/008/011/041
B125/B102

24.7000

AUTHOR: Mashkevich, V. S.

TITLE: Conditions for the occurrence of spatial dispersion in crystals

PERIODICAL: Fizika tverdogo tela, v. 4, no. 8, 1962, 2075-2080

TEXT: The spatial dispersion contained in the non-local relation $\vec{P} = (\vec{D} - \vec{\mathcal{E}})/4\pi$ is examined using

$$P_{x'}(\mathbf{r}) = \int K_{x'y'}(\mathbf{r}, \mathbf{r}')\,\mathcal{E}^{\perp}_{y'}(\mathbf{r}')\,d\mathbf{r}' \qquad (1) \text{ with}$$

$$K_{x'y'}(\mathbf{r}, \mathbf{r}') = \frac{1}{h\omega}\sum_{n}(E_n - E_0)\times$$
$$\times\left[\frac{(0|G_{x'}(\mathbf{r})|n)(n|G_{y'}(\mathbf{r}')|0)}{E_n - E_0 - h\omega - i\varepsilon_n(\omega)} - \frac{(n|G_{x'}(\mathbf{r})|0)(0|G_{y'}(\mathbf{r}')|n)}{E_n - E_0 + h\omega + i\varepsilon_n(-\omega)}\right]. \qquad (2).$$

Here $\vec{\mathcal{E}}^{\perp}(\mathbf{r})$ is the solenoidal part of the amplitude of the electric field

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Conditions for the occurrence ...

S/181/62/004/005/011/043
B125/B102

with the frequency ω. $\vec{P}(\vec{r})$ is the polarization amplitude, E_0 is the energy of the ground state, and E_n is the energy of the excited state; $\gamma_n(\omega)$ is the probability, per unit of time, of transition into the unit-interval of the frequency that corresponds to states which possess the energy $E_0 + \hbar\omega$, and $G(\vec{r})$ is the polarization operator. The degree of spatial dispersion is determined by R/λ where $R(\vec{r})$ is the effective radius of the kernel of polarizability and λ the effective wavelength of light. The spatial dispersion of the local (or non-local) excitations corresponds to the polarization caused by these excitations. It is only with $R/\lambda \gtrsim 1$ that these two variants (local and nonlocal) differ considerably from one another. There is no sharp boundary between them for impurity states with large radius or with local Wanier-Mott excitons. In the case of spatial dispersion of the non-local excitations the excited states causing polarization must belong to the quasi-continuous spectrum and $R(\vec{s})/\lambda \gtrsim 1$ must hold. This condition can be represented also as $\sqrt{l(\vec{s})/\lambda} \gtrsim 1$ where $l(\vec{s}) = \hbar k/[|m(\vec{s})| \gamma(\vec{s},\omega(\vec{s}))]$, $k = 2\pi/\lambda$. $1/\gamma$ is the lifetime of the excitons with respect to the transitions to the energy

Card 2/3

Conditions for the occurrence ...

S/181/62/004/008/011/041
B125/B102

states $E_0 + \hbar\omega(\vec{s}) = E(\vec{s})$. When excitons are produced by the excitation of the electrons then γ may depend considerably on the structure of the exciton band at sufficiently low temperatures. According to the results probably spatial dispersion of the non-local excitations does not occur except at low temperatures.

ASSOCIATION: Institut fiziki AN USSR, Kiyev (Institute of Physics AS UkrSSR, Kiyev)

SUBMITTED: March 8, 1962

Card 3/3

44158

9.2576 (also 4205)

S/181/62/004/010/055/063
B102/B104

AUTHORS: Broude, V. L., Mashkevich, V. S., Prikhot'ko, A. F., Prokopyuk, N. F. and Soskin, M. S.

TITLE: Possibility of obtaining induced radiation in systems with electron vibrational levels

PERIODICAL: Fizika tverdogo tela, v. 4, no. 10, 1962, 2976-2978

TEXT: A possibility of obtaining negative temperatures and induced radiation in a four-level scheme of molecular systems is discussed. The scheme (Figure) consists of the ground state (1), a vibrational level of the electron ground state (2), the first excited electron level (3), and the totality of all higher levels (4). 1-4 is a transition due to light-quantum absorption, 4-3 a radiationless transition, 3-2 the transition used for obtaining the induced radiation and 2-1 again a radiationless transition. The lifetimes of the radiative transitions are $\tau_r \sim 10^{-7} - 10^{-9}$sec, those of the radiationless transitions are $\tau_n \ll \tau_r'$. τ_n has to be small for obtaining the induced radiation. Generation of

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coherent induced radiation begins if $n_3 - n_2 \gtrsim 8\pi^2 c\tilde{\nu}^2 \Delta\tilde{\nu}\,\tau_0 \frac{1-R}{l}$ where n_2, n_3 are the mean numbers of molecules in state 2 or 3 per unit volume, $\tilde{\nu}$ is the wave number of the 3-2 transition, $\Delta\tilde{\nu}$ the halfwidth, R the reflection coefficient of the resonator mirror, l is the length of the sample, and τ_0 is the lifetime of state 3 with respect to the 3-2 transition. $n_3 \approx 4\tau K\eta N$, where τ is the lifetime of state 3 with respect to all other transitions to lower states, K is the mean absorption coefficient on the region of the 1-4 transition, η is the number of states 3 produced from one state 4, and N is the number of pnotons of the optical excitation 1-4 per unit of time and per unit of surface area. Numerical estimates for the anthracene molecule are presented. For $K = 2\ cm^{-1}$, $\eta = 1$, $\tau = 3 \cdot 10^{-8}$ sec and $\tau_0 = 10^{-7}$ sec one obtains $N = 4 \cdot 10^{21}\ cm^{-2}\ sec^{-1}$ which can be realized by means of an ИФК-2000 (IFK-2000) pulsed lamp. If besides $\tau_n \ll \tau_r$, $n_2 \ll n_3$, N will depend on τ_0/τ, not on τ alone. This makes it possible to draw conclusions as to the most effective form of luminescence spectrum to obtain induced radiation. A system of layers of dielectric

Card 2/4

Possibility of obtaining induced ... S/181/62/004/010/055/063
B102/B104

coatings with a certain $R(\omega)$ dependence allows of annihilating all induced radiation frequencies other than a chosen one, where R has a peak. Thus such a system can be used as an "antifilter". There is 1 figure. The most important English-language references are: W. Kaiser et al. Phys. Rev., 123, 765, 1961; E. G. Brock et al. J. Chem. Phys. 35, 759, 1961.

ASSOCIATION: Institut fiziki AN USSR, Kiyev (Institute of Physics AS UkrSSR, Kiyev)

SUBMITTED: June 6, 1962

Card 3/4

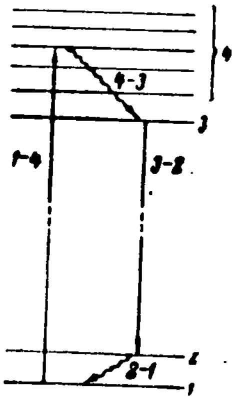

Fig.

S/181/62/004/011/034/049
B108/B102

AUTHOR: Mashkevich, V. S.

TITLE: Absorption and dispersion of light in the region of exciton junctions

PERIODICAL: Fizika tverdogo tela, v. 4, no. 11, 1962, 3279 - 3285

TEXT: The effect of spatial dispersion on the dispersion and absorption of light around exciton transitions is studied for the case of weak exciton-phonon coupling. The Maxwell equations are solved by a method developed previously (ZhETF, 38, 906, 1960; 40, 1803, 1961). The effect of spatial dispersion increases with increasing oscillator strength of the transition, with increasing mean free time of the virtual exciton, and with increasing width of the exciton band. This effect may be considerable, particularly at low temperatures. The spatial dispersion leads to a violation of the Kramers-Kronig relations when the mean free time of the virtual exciton is long enough. When linearly polarized light falls perpendicularly onto a plane parallel plate, the width of the region in which the spatial dispersion becomes effective is small as compared with the width of the exciton band.

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S/181/62/004/011/034/049
Absorption and dispersion of light... B108/B102

ASSOCIATION: Institut fiziki AN USSR, Kiyev (Physics Institute AS UkrSSR, Kiyev)

SUBMITTED: June 1, 1962 (initially)
July 3, 1962 (after revision)

Card 2/2

S/056/62/042/001/022/048
B104/B102

[illegible]

AUTHOR: Mashkevich, V. S.

TITLE: Electromagnetic waves in a medium possessing a continuous energy spectrum. III

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 1, 1962, 135-143

TEXT: The theory of electromagnetic waves in a crystal in the presence of spatial dispersion due to exciton states was applied to a number of problems in previous papers (ZhETF, 38, 906, 1960; 40, 1803, 1961). The solution of Maxwell equations for a nonconductive medium was presented in I. The propagation of perpendicularly incident waves through a plate (cubic crystal) was examined in II without allowing for birefringence. The birefringence due to spatial dispersion is now taken into account. Using results and symbols of the previous papers and assuming optical anisotropy for a cubic crystal, the following relations are obtained for the amplitudes of incident, reflected, and transmitted waves:

1X

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S/056/62/042/001/022/048
B104/B102

Electromagnetic waves in a medium...

$$R_n = \mathcal{E}_n \frac{1 - G_n^2 + F_n^2}{G_n^2 + (1 + iF_n)^2}, \qquad D_n = \mathcal{E}_n \frac{i2G_n \exp(-ik_0 l)}{G_n^2 + (1 + iF_n)^2}. \qquad (4).$$

$$F_n = f_{n1} \operatorname{ctg} \varkappa_{n1} l + f_{n2} \operatorname{ctg} \varkappa_{n2} l, \quad G_n = f_{n1} / \sin \varkappa_{n1} l + f_{n2} / \sin \varkappa_{n2} l,$$

$$f_{n1} = \frac{\varkappa_{n1} / k_0}{1 - (\varkappa_{n2}^2 - k_n^2) / (\varkappa_{n1}^2 - k_n^2)}.$$

f_{n2} is obtained from f_{n1} by permutation of subscripts 1 and 2; $\kappa_{n1,2}^2$ are the roots of the equation

$$-\varkappa^2 + \gamma (1 + 4\pi\beta) + B/(\xi_n \varkappa^2 - i\varepsilon_n - \zeta) = 0,$$
$$B = 4\pi\gamma L^2 l \,|\, \mathbf{P}_{a\perp} |^2 \, [E(0, a\perp) - E_0] / \hbar\omega,$$
$$\xi_n = \hbar^2 / 2m_n^*, \quad \zeta = E_0 + \hbar\omega - E(0, a\perp).$$

Card 2/4

where m_n denotes the effective mass for the direction $\vec{k}$, perpendicular to the plate; β allows for the local part of polarization; k_n is the root of the equation $\xi_n k^2 - i\varepsilon_n - \zeta = 0$. If m_1 and m_2 differ noticeably, birefringence will take place. The penetration of a plane-parallel plate by a wave incident at an arbitrary angle is considered. Restricting oneself to a semi-infinite crystal, the following generalized Fresnel formulas are obtained:

$$R_{2y} = \mathcal{E}^0_{2y} \frac{f_{13}^{--} f_{42}^{+-} - \exp(i2\varkappa_4 l) f_{14}^{--} f_{23}^{+-}}{-f_{13}^{--} f_{42}^{++} + \exp(i2\varkappa_4 l) f_{14}^{--} f_{23}^{++}},$$

$$D_{2y} = -\mathcal{E}^0_{2y} 2q_0 p_3^{+} \begin{vmatrix} 1 & 1 & 1 \\ q_1 & q_3 & q_4 \\ p_1^- & p_3^- & p_4^- \end{vmatrix} \exp[i(\varkappa_4 - k_{0z}) l] \times$$
$$\times [-f_{13}^{--} f_{42}^{++} + \exp(2i\varkappa_4 l) f_{14}^{--} f_{23}^{++}]^{-1}. \qquad (14).$$

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S/056/62/042/001/022/048
B104/B102

Electromagnetic waves in a medium...

The longitudinal components of the electric field of a light wave are calculated, and the results are compared with the corresponding results of S. I. Pekar's theory (ZhETF, 34, 1176, 1958). The latter is criticized in connection with the case of oblique incidence of a longitudinal and a transverse wave field. There are 11 references: 10 Soviet and 1 non-Soviet.

ASSOCIATION: Kiyevskiy politekhnicheskiy institut (Kiyev Polytechnic Institute)

SUBMITTED: April 25, 1961

Card 4/4

MASHKEVICH, V.S.

L 17799-63 EWA(k)/EWP(k)/EWP(q)/EWT(m)/BDS/EEC(b)-2/ES(t)-2
AFFTC/ASD/ESD-3/RADC/APGC/AFWL/IJP(C)/SW2 Pf-4/Pi-4 GG/WH/JHB/WG/K
ACCESSION NR: AP3006823 S/0185/63/008/008/0915/0918

82
80

AUTHOR: Mashkevych, V. S.

TITLE: Concerning the concepts of negative absorption and negative temperature 21

SOURCE: Ukrains'kyy fizychnyy zhurnal, v. 8, no. 8, 1963, 915-918

TOPIC TAGS: laser, maser, negative absorption, population inversion, negative temperature, laser theory, negative absorption factor

ABSTRACT: The concepts of negative absorption and negative temperature have been examined and compared in their applicability to laser phenomena. It is shown that the two concepts are equivalent 1) in the case of transitions within one pair and 2) in the case of transitions between two groups of stationary states containing an identical number of states per group with equal transition probabilities within each group. An example of a case

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L 17799-63
ACCESSION NR: AP3006823

where the two concepts are equivalent is the four-level laser at sufficiently low temperature. In the general case, however, where there is no even population of states within a group (e.g., at sufficiently low temperature) or when the numbers of states in the two groups are not equal, the two concepts are no longer equivalent. If transitions occur among several pairs of states, there may not be any negative temperature (population inversion) for some pairs of states in the presence of negative absorption at some modes, and only the concept of negative absorption applies. A Stokes shift of absorption and luminescence spectra, for instance, is sufficient to render the two concepts nonequivalent. The ruby laser is a case in which the decrease of threshhold with temperature (resulting from the Stokes shift) cannot be explained on the basis of temperature inversion. Orig. art. has: 5 equations.

ASSOCIATION: Instytut fizyky AN URSR, Kiev (Physics Institute, AN URSR)

SUBMITTED: [illegible]Apr63
DATE ACQ: [illegible]
ENCL: 00
SUB CODE: PH
NO REF SOV: 001
OTHER: 002

Card 2/2

MASHKEVICH, V.S. [Mashkevych, V.S.]

A laster based on Raman scattering. Ukr. fiz. zhur. 8 no.9: 1032-1035 S '63.

Nonlinear optical properties of a three-level system in a resonator with several modes. Ibid.:1035-1038 (MIRA 17:8)

1. Institut fiziki AN UkrSSR, Kiyev.

L 46297-65 EWG(j)/EWT(1)/EPA(s)-2/EWT(m)/EPF(c)/EPR/EWP(t)/EWP(b) Pr-4/Ps-4/
Pt-7 IJP(c) GG/JD

UR/0058/65/000/003/D024/D024

ACCESSION NR: AR5012239

52
B

SOURCE: Ref. zh. Fizika, Abs. 3D166

AUTHOR: Mashkevich, V. S.

21

TITLE: Exchange mechanism of bimolecular electronic transitions in oxygen

CITED SOURCE: Tr. Komis. po spektroskopii. AN SSSR, vyp. 1, 1964, 585-590

TOPIC TAGS: electronic transition, oxygen, bimolecular transition, absorption spectrum, exchange mechanism, antiferromagnetism

21

TRANSLATION: The absorption spectrum of oxygen contains two weak lines corresponding to the forbidden transitions $^3\Sigma_g^- \to {}^1\Sigma_g^+, {}^1\Delta_g$. The lines with double and summary frequencies acquire an intensity of the same order at sufficiently high molecule concentration. They are ascribed to electronic transitions which occur simultaneously in two molecules. By way of the possible mechanism for double and ordinary transitions when two molecules come close together, the author considers the exchange mechanism. Evidence in its favor is given in the lifting of the intercombinational forbiddenness and equalization of the intensities of double and ordi-

Card 1/2

L 16297-65

ACCESSION NR: AR5012239

nary transitions. The role of this mechanism can be clarified by investigating spectra in strong magnetic fields. Its connection with the antiferromagnetism of oxygen is discussed.

SUB CODE: IC, OP ENCL: 00

Card 2/2

L 33166-66 EWT(1) IJP(c) WW/GG

ACC NR: AR6016199 SOURCE CODE: UR/0058/65/000/011/D030/D031

37
B

AUTHOR: Mashkevich, V. S.; Strashnikova, M. I.

TITLE: Possible manifestation of additional waves in the reflection of light from crystals

SOURCE: Ref. zh. Fizika, Abs. 11D234

REF SOURCE: Tr. Komis. po spektroskopii. AN SSSR, t. 3, vyp. 1, 1964, 448-453

TOPIC TAGS: light reflection, exciton absorption, refractive index, cadmium sulfide

ABSTRACT: It is indicated that usually the manifestation of additional light waves in the region of exciton absorption of the crystal has been considered only in connection with the passage of two waves through a thin plate. At the same time, additional waves can always greatly influence the reflection, too. Especially characteristic is the case when the refractive indices of the two waves satisfy the relation $n_2^2 - n_1^2 > 0$. Then the additional wave can greatly influence the phase of the reflected wave. The CdS crystal is considered as an example. [Translation of abstract]

SUB CODE: 20/

LS
Card 1/1

ACCESSION NR: AP4041706 S/0181/64/006/007/2037/2046

AUTHOR: Vinetskiy, V. L.; Mashkevich, V. S.; Tomchuk, P. M.

TITLE: Theory of stationary radiation induced by interband transitions

SOURCE: Fizika tverdogo tela, v. 6, no. 7, 1964, 2037-2046

TOPIC TAGS: laser effect, laser emission, laser pumping method, stimulated emission, transition frequency

ABSTRACT: A kinetic equation method developed by the author for the analysis of stimulated emission (UFZh v. 8, 918, 1963) is used to determine the parameters of the singular modes at which laser action can be achieved. These parameters are then used to determine the threshold value of the pump signal. It is assumed that only direct transitions are effective, the electron and hole bands are spherical, the electrons and holes have equal effective masses, each band is in

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ACCESSION NR: AP4041706

statistical equilibrium, and the system is spatially homogeneous. It is shown that an important factor in the feasibility of laser action is the spacing of the singular modes, and monochromatic emission is possible in principle if the spacing is large. Future plans call for investigations of induced emission for systems with impurities and the use of x-rays or gamma rays for pumping. Orig. art. has: 56 formulas.

ASSOCIATION: Institut fiziki AN UkrSSR Kiev (Institute of Physics, AN UkrSSR)

SUBMITTED: 24Feb64 ATD PRESS: 3076 ENCL: 00

SUB CODE: EC, GP NR REF SOV: 004 OTHER: 004

Card 2/2

MASHKEVICH, V.S. [Mashkevych, V.S.]

Laser with two types of active centers. Ukr. fiz. zhur. 9 no.11: 1260-1263 N '64. (MIRA 17:9)

1. Institut fiziki AN UkrSSR, Kiyev.

MASHKEVICH, V. S.

ACCESSION NR: AP4012027 S/0185/64/009/001/0014/0025

AUTHOR: Buryakivs'ky*y, G. Yu.; Mashkevy*ch, V. S.

TITLE: Theory of stationary radiation of a homogeneous system in a multimode resonator. 1. Dependence of radiation on the swing

SOURCE: Ukrayins'ky*y fizy*chny*y zhurnal, v. 9, no. 1, 1964, 14-25

TOPIC TAGS: laser, maser, resonator, resonator mode, laser theory, swing, multimode resonator, kinetic equations

ABSTRACT: The present work was undertaken to solve the problem, in laser theory, of determining the modes at which generation should occur. In previous work by one of the authors it was shown that, by using the method of kinetic equations, a number of true results can be obtained in the case of a stationary regime; he succeeded in investigating nonlinear properties during weak swings and in proving the existence of a sharply expressed threshold of generations. In doing so, a large number of modes and, since the field was considered in a quantum mechanical sense, spontaneous radiation were consistently taken into account. The present work continues the investigation. Using the method of kinetic equations the

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ACCESSION NR: AP4012027

authors develop the theory of the stationary radiation of a homogeneous system in a resonator where there is a great number of resonator modes within the width of the radiation line. (Because of the extreme complexity of the problem of heterogeneous systems, investigation of homogeneous systems is a necessary step, even though it must still be determined whether a laser can be considered a homogeneous system.) The finding that the intensity of radiation of the resonator mode is a function of the swing in regions of weak and strong swings is a real step forward which permitted obtaining very detailed information on the properties of the system and the radiation. It is shown that if the number of modes at which considerable generation of induced radiation occurs is small in comparison with the full number of modes, there is a pronounced threshold value of the swing. The width of the threshold region is found. Orig. art. has 85 formulas.

ASSOCIATION: Insty*tut fizy*ky* AN UkrRSR, Kiev (Institute of Physics, AN UkrRSR)

SUBMITTED: 08May63 DATE ACQ: 14Feb64 ENCL: 00

SUB CODE: PH, AS NO REF SOV: 002 OTHER: 006

Card 2/2

ACCESSION NR: AP4017404 S/0185/64/009/002/0226/0229

AUTHOR: Meshkevy*ch, V. S.

TITLE: Radiation of the second optical harmonic

SOURCE: Ukrayins'ky*y fizy*chny*y zhurnal, v. 9, no. 2, 1964, 226-229

TOPIC TAGS: electrodynamics, laser, quantum mechanics, crystal radiation, optical harmonic, perturbation analysis, combinatorial scattering, phonon

ABSTRACT: The high power levels obtained from present day lasers create conditions favorable to the generation of the second optical harmonics in crystals. The classical theory of electrodynamics is not applicable because of relatively high second harmonic power levels and because the reverse process, i.e. recombination of the second harmonic radiation to give the fundamental frequency, is non-singular (1 quantum of the second harmonic radiation yields 2 quanta at the fundamental and vice versa). Hence, a quantum mechanical analysis becomes necessary. The simplest model, having only one mode at the fundamental frequency and one mode at the second harmonic, is assumed. For a stationary system, with spontaneous radiation at the second harmonic frequency, the condition under which the second harmonic radiation efficiency, η, becomes approximately 100% is

$$2a_1 < a_p \qquad (1)$$

Card 1/3

where α_1 and α_2 are losses associated with the actual propagation modes of the fundamental and the second harmonic components, respectively. The inequality (1) assumes very large values of N_1, the pump level at the frequency and the mode of the fundamental component. If q_1 is the number of quanta in the fundamental mode and if $q_1 \gg 1$ then the assumption of large N_1 simplifies to:

$$N_1 \gg \frac{\alpha_1}{2B}. \qquad (2)$$

where B is the probability of transition of two quanta of the fundamental mode into 1 quantum of the second harmonic mode. Thus, when the basic inequality (1) is satisfied and when the external losses at the second harmonic frequency are low, the pump levels which satisfy (2) give $\eta \approx 1$. The classical approach gives the erroneous answer that $\eta \approx 1$ can be achieved independently of the values of α_1 and α_2. Perturbation analysis of the spontaneous stationary system with the above assumptions shows that it is stable. When the refractive indices at the fundamental and second harmonic frequencies are equal, a maximum transition probability B results and, for some realistic parameters, the inequality (2) gives $N_1 \gg 0.5 \times 10^{22}\text{sec}^{-1}$. This level is achievable with ruby laser radiation. It is the author's opinion that values of $\eta \approx 1$ were not achieved until now because the basic requirement as expressed by inequality (1) was not understood and not fulfilled. Examination of an induced radiation system shows that the generation of the second harmonic is analogous to combinatorial scattering. The basic diffi-

ACCESSION NR: AP4017404

culty arises from the fact that the coherency volume is limited by the free path length of a phonon, indicating the requirement of low temperatures for induced generation of the second harmonic. Orig. art. has: 25 formulas.

ASSOCIATION: INSTY*TUT FIZY*KY* AN URSR, [redacted] (Institute of Physics, Academy of Sciences of the Ukrainian SSR)

SUBMITTED: 08Oct63	DATE ACQ: 19Mar64	ENCL: 00
SUB CODE: GP	NO REF SOV: 003	OTHER: 003

Card 3/3

L 14817-65 EWA(k)/EWT(l)/EEC(k)-2/T/EEC(b)-2/EWP(k)/EWA(m)-2 Po-4/Pf-4/Pi-4/
Pl-4 IJP(c)/RAEM(i)/ESD(t) WG/JHB

ACCESSION NR: AP4044177 S/0185/64/009/008/0921/0925

B

AUTHOR: Marushko, I. O.; Mashkevy*ch, V. S.

TITLE: Generation of the second harmonic in a plane-parallel plate

SOURCE: Ukrayins'ky*y fizy*chny*y zhurnal, v. 9, no. 8, 1964, 921-925

TOPIC TAGS: second harmonic, plane parallel plate, nonlinear Maxwell equation, quantum transition

ABSTRACT: Several papers were dedicated to the derivation of the generation of the second harmonic on the basis of the nonlinear Maxwell equations. The present paper derives the same results by the method of quantum transitions. Orig. art. has: 2 figures, 11 equations.

ASSOCIATION: Institut fiziki AN URSR, Kiev (Institute of physics AN URSR)

SUBMITTED: 15Apr64 ENCL: 00

Card 1/2

L 14817-65

ACCESSION NR: AP4044177 0

SUB CODE: ME NO REF SOV: 002 OTHER: 006

Card 2/2

ACCESSION NR: AP4048871 S/0185/64/009/010/1146/1150

AUTHOR: Marushko, I. O.; Mashkevych, V. S. B

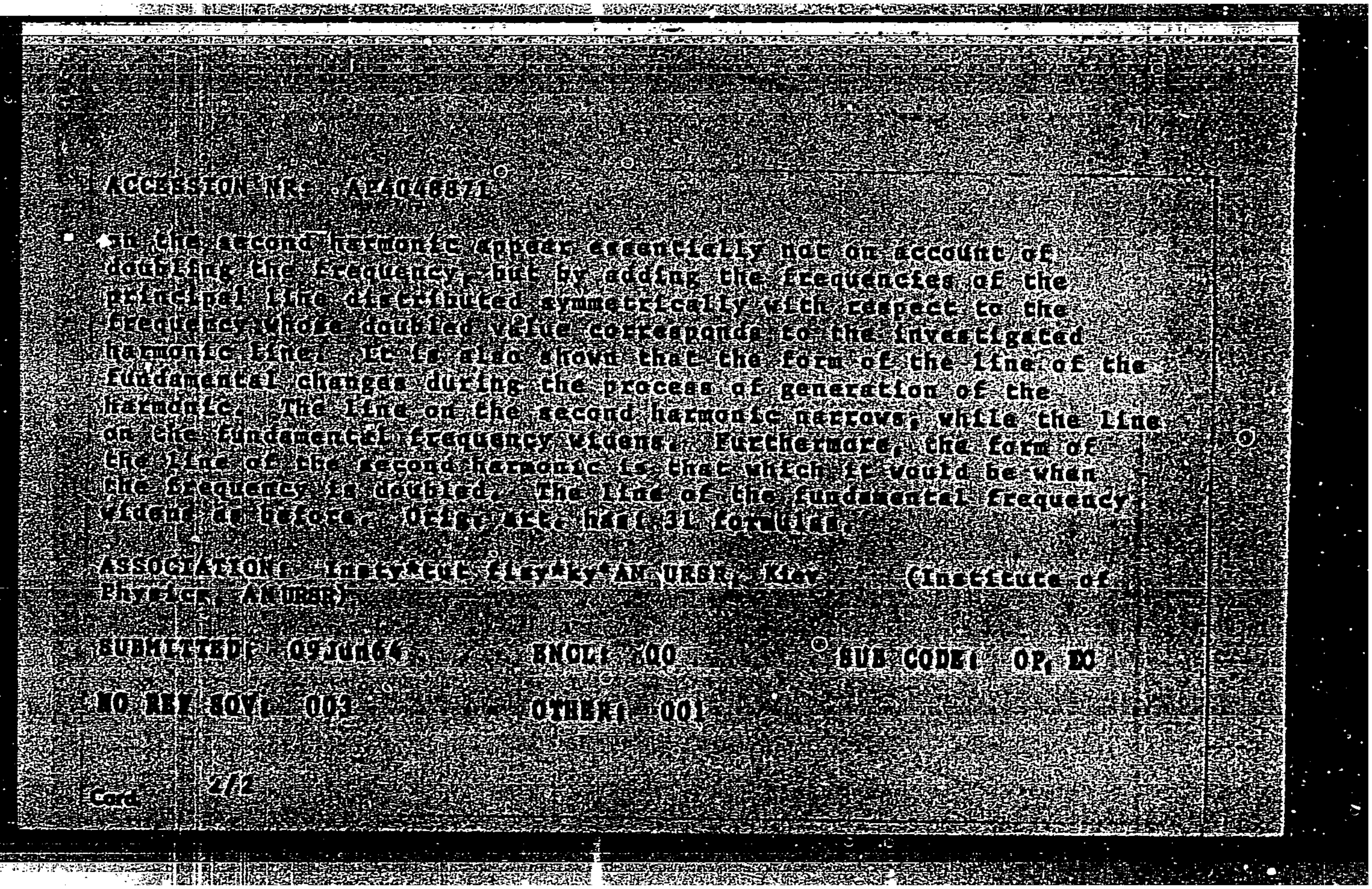
TITLE: Form of the line while generating the second optical harmonic

SOURCE: Ukrayins'kyy fizy*chnyy zhurnal, v. 9, no. 10, 1964, 1146-1150

TOPIC TAGS: second optical harmonic, second harmonic, principal frequency, spectral width of radiation

ABSTRACT: In problems concerning the generation of the second harmonic, the field of the fundamental frequency was regarded as a plane monochromatic wave. Laser radiation, which is suited to generating harmonics, has a finite spectral width. The generation of the second harmonic in a stationary regime when the shape of the line of pumping at the fundamental frequency is given, was investigated. In addition, a line with finite width was regarded as a combination of monochromatic lines which correspond to normal oscillations of the electromagnetic field distributed with appropriate density. It is shown that corresponding monochromatic lines

Card 1/2



ACCESSION NR: AP4046871

in the second harmonic appear essentially not on account of doubling the frequency, but by adding the frequencies of the principal line distributed symmetrically with respect to the frequency whose doubled value corresponds to the investigated harmonic line. It is also shown that the form of the line of the fundamental changes during the process of generation of the harmonic. The line on the second harmonic narrows, while the line on the fundamental frequency widens. Furthermore, the form of the line of the second harmonic is that which it would be when the frequency is doubled. The line of the fundamental frequency widens as before. Orig. art. has: 31 formulas.

ASSOCIATION: Insty*tut fizy*ky* AN URSR, Kiev (Institute of Physics, AN URSR)

SUBMITTED: 09Jun64 ENCL: 00 SUB CODE: OP, EC

NO REF SOV: 003 OTHER: 001

Card 2/2

L 44153-65 EEC(b)-2/EWG(r)/EEC(k)-2/EWA(h)/EWA(k)/EWP(k)/EWT(l)/EEC(t)/FSD/
EWA(m)-2 Pf-4/Pi-4/Pl-4/Pm-4/Pn-4/[illegible]-4/Pz-6/Peb IJP(c) AT/WG

ACCESSION NR: AP5010707 UR/0181/65/007/004/

AUTHOR: Buryakovskiy, G. Yu.; Vinetskiy, V. L.; Mashkevich, V. S.

TITLE: Theory of laser emission at band to band transitions in an impur-
conductor

25

SOURCE: Fizika tverdogo tela, v. 7, no. 4, 1965, 1028-1036

TOPIC TAGS: laser, semiconductor laser, oscillation condition, stimulated emission, oscillation threshold

ABSTRACT: The theory of steady-state laser emission at interband transitions of an intrinsic semiconductor developed by V. A. Vinetskiy, V. S. Mashkevich, and P. M. Tomchuk (Fizika tverdogo tela, v. 7, no. 6, 1964, pp. 2037-2046) is extended to the case of an impurity semiconductor. The authors utilize the "kinetic equations method" developed by V. S. Mashkevich in 1963, which in calculating the oscillation threshold, makes it possible to take into account both spontaneous and stimulated transitions. In developing a consistent theory the authors assume that there are only band-to-band transitions, that the electron and hole bands are spherical, that the effective electron and hole masses are equal, that a statistical equilibrium exists in every band, and that the system is spatially homogeneous. The frequency of the oscillation mode for laser emission and the

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L 44153-65

ACCESSION NR: AP5010707

location of the Fermi levels in both bands are calculated. An expression is derived for the oscillation threshold. The dependence of these quantities on the impurity concentration is investigated. In many cases the results obtained differ considerably from the results of the theory which does not take into account stimulated transitions in oscillation modes other than those responsible for laser action. Since intraband absorption was not taken into account, the results apply only to laser systems at sufficiently low temperatures. Orig. art. has: 56 formulas and 1 table. [CS]

ASSOCIATION: Institut fiziki AN UkrSSR, Kiev (Physics Institute, AN UkrSSR)

SUBMITTED: 17Sep64 ENCL: 00 SUB CODE: EC

NO REF SOV: 001 OTHER: 004 ATD PRESS: 3248

Card 2/2

L 53577-65 EWA(k)/FBD/EWG(r)/EWT(1)/EEC(k)-2/EEC(t)/T/EEC(b)-2/EWP(k)/EWA(m)-2/
EWA(h) Pn-4/Po-4/Pe-6/Po-4/Pf-4/Peb/Pi-4/Pl-4 UR/0181/65/007/006/1898/1899
ACCESSION NR: AP5014609 SCTB/IJP(c) WG/AT

62
61
B

AUTHOR: Vinetskiy, V. L.; Mashkevich, V. S.

TITLE: Laser action by means of direct transitions in a semiconductor

21

SOURCE: Fizika tverdogo tela, v. 7, no. 6, 1965, 1898-1899

TOPIC TAGS: band to band transition, direct transition, semiconductor laser, exciton transition

25

ABSTRACT: In an earlier work (FTT, 6, 1964, 2037) in collaboration with P. M. Tomchuk, the authors developed a detailed theory of a laser model based on direct band-to-band transitions, for which they computed the frequency of the fundamental mode, the position of the Fermi quasi-levels, and the threshold value of the pumping energy. In the present work a critical examination is made of such a laser model. According to the authors' earlier calculations, the carrier concentrations required to achieve a steady-state laser emission are of the order of

$$C=2\left(\frac{8m}{[illegible]}\right)^{[illegible]}$$

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L 53517-65

ACCESSION NR: AP5014609

where $\beta = kT$ and m is the effective carrier mass. At

$$T > 1^{\circ}K, C \geq 10^{16}-10^{18}\ cm^{-3}$$

At such concentrations the probability of electron-hole bonding into excitons is comparatively high, and the effect of such losses on laser action is explained. A laser model based on direct band-to-band transitions in which no excitons play a part is held to be possible only at extremely low temperatures and suitable laser parameters. On the other hand, it is concluded that at sufficient exciton concentrations a laser based on direct exciton transitions is possible in principle, although D. G. Thomas and J. J. Hopfield (J. Appl. Phys., 33, 1962, 3243) disagree with this conclusion. Without going deep into theory, the authors claim that such a laser would require a very low threshold pumping energy. Orig. art. has: 2 formulas.

[YK]

ASSOCIATION: Institut fiziki AN UkrSSR, Kiev (Physics Institute, AN UkrSSR)

SUBMITTED: 25Jan65 ENCL: 00 SUB CODE: EC

NO REF SOV: 001 OTHER: 002 ATD PRESS: 4015

Card 2/2

L 39915-65 EEC(b)-2/EWG(r)/EEC(k)-2/EWA(h)/EWA(k)/EWP(k)/EWT(1)/EE?(t)/FBD/T/
EWA(m)-2 Pf-4/Pi-4/Pl-4/Pm-4/Pn-4/Po-4/Peb IJP(c) WG

ACCESSION NR: AP5004323 S/0185/65/010/001/0055/0064

45
44
B

AUTHOR: Mashkevych, V. S. (Mashkevich, V. S.)

25

TITLE: The problem of instability in stationary radiation of a laser

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 1, 1965, 55-64

TOPIC TAGS: laser, laser radiation, laser stationary radiation, laser radiation instability, positive absorption center, negative absorption center

ABSTRACT: A simple model is used to show that the effect of the instability of a stationary regime can be achieved with the aid of the kinetic equation method and that the physical nature of this instability can be explained. It is also shown that a method of single-frequency oscillations in a nonlinear system with many degrees of freedom can be used for the investigation of radiation oscillations. A case of several special modes interacting with centers of several kinds was investigated. It is concluded that in the case of an inhomogeneous system at a multimode generation the presence of centers with a positive absorption can cause a stationary instability. It is

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L 39915-65

ACCESSION NR: AR5004323

necessary, however, that the special modes be supplied, at least partially, by common centers with negative absorption. Otherwise, a combination of independent single-mode generations will take place and the stationary regime will be stable. In solid-body lasers, the presence of centers with positive absorption at frequencies of special modes is quite probable. They can be represented by atoms of the main substance, atoms of foreign matter, or by active centers which have been poorly pumped because of the inhomogeneity of the pumping. Orig. art. has: 50 formulas. [JA]

ASSOCIATION: Instytut fizyky AN URSR, Kiev (Physics Institute, AN UkrSSR)

SUBMITTED: 27Apr64 ENCL: 00 SUB CODE: EC

NO REF SOV: 005 OTHER: 004 ATD PRESS: 3189

Card 2/2

L 26946-65 EWA(k)/FBD/EWG(r)/EWT(1)/EEC(k)-2/EEC(t)/T/EEC(b)-2/EWP(k)/EWA(m)-2/EWA(h)
ACCESSION NR: AP5004324 Pm-4/Pn-4/Po-4/ S/0185/65/010/001/0065/0075
Pf-4/Pi-4/Pl-4/Peb SCTB/IJP(c) WG

64
63
B

AUTHOR: Buryakivs'kyy, H. Yu. (Buryakovskiy, G. Yu.); Mashkevych, V. S. (Mashkevich, V. S.)

TITLE: Dynamics of laser radiation with variable losses

25

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 1, 1965, 65-75

TOPIC TAGS: laser, laser radiation, pumping, absorption, giant laser oscillation

ABSTRACT: In laser theory, the problem of losses of resonator modes changing with time is very important. The losses of resonator modes are closely associated with the appearance of giant oscillations of laser radiation. When the pumping of the laser takes place with large losses of the resonator modes an overpopulation of active centers is produced. A rapid decrease of losses results in a sharp increase in radiation, which results in the appearance of giant oscillations. Previous investigations of this problem showed that the decrease in losses ended before the emergence of the giant oscillations. The object of the present study was to determine how the losses depend on

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L 26946-65
ACCESSION NR: AP5004324

time. Only giant oscillations were considered. The time dependence of the losses was assumed to be linear. A three-level homogeneous system was studied using the method of kinetic equations. The population of the third level was disregarded. This is possible when the pumping falls short of total saturation. Only the modes participating in the generation were taken into account. For the sake of simplicity, a case of weak absorption of pumping was considered. It was found that the following condition must be satisfied for the appearance of maximum giant oscillations: $\theta \geq \theta_{min}$, where

$$\theta_{min} = \alpha_0^2/2\ln\frac{N_0}{q_0},$$

q is the number of quanta of all special modes, N is the overpopulation, and α characterizes the loss of modes. Orig. art. has: 2 figures and 77 formulas. [JA]

ASSOCIATION: Institut fiziki AN UkrSSR, Kiev (Institute of Physics, AN UkrSSR)

Card 2/3

L 34832-65 EWG(j)/EWA(k)/FBD/EWT(1)/EEC(k)-2/EEC(t)/T/EEC(b)-2/EWP(k)/EWA(m)-2/
EWA(h) Pn-4/Po-4/Pf-4/Pi-4/Pl-4/Peb IJP(c) WG

ACCESSION NR: AP5007691 S/0185/65/010/003/0312/0322

AUTHOR: Marushko, I. O. (Marushko, I. A.); Mashkevych, V. S. (Mashkevich, V. S.)

TITLE: Generation of the second optical harmonic in a laser resonator

25

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 3, 1965, 312-322

TOPIC TAGS: laser, laser resonator, second optical harmonic, harmonic generation, particular mode, crystal nonlinearity

ABSTRACT: The effect of second harmonic generation on laser operation and the conditions for the most effective transformation of the fundamental frequency into the harmonic in a continuous-wave mode have been investigated using the kinetic equation method. A simple laser model with a single mode was used. The effect of the generation of a harmonic on the particular mode was found to be weak. The number of second harmonic quanta clearly depends on the pump power. In the case of very high pump power, the pumping and losses of the particular mode (α_1) determine the transformation coefficient (k). By reducing α_1, it is possible to obtain a k value close to unity. In a case corresponding to the saturation of the second harmonic (when the number of photons in the mode does not depend on the nonlinearity of the crystal), the radiation of the particular mode depends essentially on the losses of the harmonic α_2. Only the effectiveness of harmonic generation is determined from the ratio

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L 34882-65

ACCESSION NR: AP5007691

of the losses of the fundamental frequency and the harmonic. To limit the radiation of non-particular modes in this region, i.e., to retain the particular mode, the losses of the harmonic α_2 should be restricted. In the region of the strong generation of harmonics, the role of the reverse process (i.e., the transformation of a harmonic into a fundamental frequency) increases, thus reducing the effective losses of the particular mode. A decrease of α_2 furthers the process. Thus, for stable laser operation and maximum generation of a harmonic, an optimum ratio of losses α_1 and α_2 should be selected. Orig. art. has: 27 formulas. [JA]

ASSOCIATION: [illegible] AN UzSSR ([illegible] AN UzSSR)

SUBMITTED: 07Jul64 ENCL: 00 SUB CODE: EC

NO REF SOV: 007 OTHER: 004 ATD PRESS: 3212

Card 2/2

L 44787-65 EWA(k)/FBD/EWG(r)/EWT(1)/EEC(k)-2/EEC(t)/T/EEC(b)-2/EWP(k)/
EWA(m)-2/EWA(h) Pm-4/Pn-4/Po-4/Pf-4/Pi-4/Pl-4/Peb SCTB/IJP(c) WG

ACCESSION NR: AP5011066 UR/0185/65/010/004/0398/0409

AUTHOR: Buryakivs'kyy, H. Yu. (Buryakovskiy, G. Yu.); Mashkevych, V. S. (Mashkevich, V. S.)

60
B

55

TITLE: Dynamics of emission of a laser with variable losses. II.

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 4, 1965, 398-409

TOPIC TAGS: laser emission, giant oscillation, laser cavity, population inversion, laser radiation density, laser radiation flux, laser

ABSTRACT: This is a continuation of an earlier paper (Ukr. fizychn. zh. v. 10, no. 1, 1965) in which 1) a general method was developed for solving the kinetic equation describing the behavior of a laser with variable losses and 2) the case of a large initial excess population was considered. In the present paper, the general results of the earlier work are used to analyze the case of relatively small initial excess population, corresponding to relatively slow variation of the cavity losses, which is easier to realize in practice than the first case. The equations of the first part of the paper are modified and solved by successive approximation. The critical conditions under which giant oscillations occur are then considered. The

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L 44787-65

ACCESSION NR: AP5011066 3

conditions under which a maximum radiation density is obtained inside the cavity and the maximum radiation flux can flow out of the cavity are determined. The generality of the earlier and of the present results is limited only by the facts that the kinetic-equation method is used, that the system is assumed homogeneous, that the one-mode approximation is employed, and that the time-dependence of the losses is assumed linear. Within these limitations, the results provide a complete description of emission from a laser with variable losses, especially the giant oscillations. "The authors thank V. L. Broude and M. S. Soskin for useful discussions and continuous interest." Orig. art. has: 3 figures and 80 formulas. [02]

ASSOCIATION: Instytut fizyky AN UkrSSR, Kiev [Institut fiziki AN UkrSSR] (Physics Institute, AN UkrSSR)

SUBMITTED: 09Jun64 ENCL: 00 SUB CODE: EC

NO REF SOV: 001 OTHER: 002 ATD PRESS: 3257

[redacted]

Card 2/2

L 58969-65 EWT(1)

ACCESSION NR: AP5017905

UR/0051/65/019/001/0136/0138
621.375.9:535.375

AUTHOR: Marushko, I. A.; Mashkevich, V. S.

TITLE: Line width of stimulated Raman scattering 21

SOURCE: Optika i spektroskopiya, v. 19, no. 1, 1965, 136-138

TOPIC TAGS: SRS, Raman line, line width, Raman effect laser, nonlinear optics

ABSTRACT: The line width of stimulated Raman scattering (SRS) is investigated under stationary and quasi-stationary conditions where pumping at the fundamental frequency is constant with time. The problem was solved by means of the kinetic equations method derived previously (V. S. Mashkevich, Ukr. fiz. zh. 9, 1032, 1963). The line shape was assumed to be that of a Lorentz curve. The explicit dependence of the SRS line width on the pumping was determined for regions above and below the threshold value of the pumping. In the cases considered, as in the usual laser, a sharp narrowing of the line occurs when pumping is increased beyond the threshold. Orig. art. has: 5 formulas. [YK]

ASSOCIATION: none

Card 1/2

L 58963

ACCESSION NR: AP5017905

SUBMITTED: 24Nov64 ENCL: 00 SUB CODE: EC, OP

NO REF SOV: 004 OTHER: 003 ATD PRESS: 4048

Card 2/2

VINETSKIY, V.L.; MASHKEVICH, V.S.

Generation of laser radiation in direct transitions in a semiconductor. Fiz. tver. tela 7 no.6:1898-1899 Je '65. (MIRA 18:6)

1. Institut fiziki AN UkrSSR, Kiyev.

L 58871-65 EEC(b)-2/EWA(h)/EWG(r)/EEC(k)-2/EWA(k)/[illegible]/EWT(1)/FBD/T/EWA(m)-2
Pf-4/Pi-4/Pl-4/Pm-4/Pn-4/Po-4/Peb SCTB/IJP(c) WG

ACCESSION NR: AP5017287 UR/0181/65/007/007/1987/1993

AUTHOR: Mashkevich, V. S.; Vinetskiy, V. L.

62
61
B

TITLE: Theory of laser emission on indirect band-to-band transitions

15

SOURCE: Fizika tverdogo tela, v. 7, no. 7, 1965, 1987-1993

TOPIC TAGS: laser, semiconductor laser, indirect transition, indirect transition laser, quasi Fermi level, oscillation criteria, oscillation threshold, pump power

ABSTRACT: Using kinetic equations, the authors develop a theory for an indirect semiconductor laser not containing impurities. The analysis is limited to steady-state operation involving generation of one optical phonon. Expressions are derived for the quasi-Fermi level, the oscillation frequency of the mode responsible for generation, and the threshold pump power. In the case of Boltzmann distribution, it is shown that at low temperatures the pump threshold for an indirect transition laser is smaller by several units of ξ than that of a direct band-to-band transition laser (ξ is the ratio of the average losses in modes other than the mode responsible for laser action to the loss in the oscillation mode). Orig. art. has: 30 formulas. [CS]

Card 1/1

L 58871-65

ACCESSION NR: AP5017287

ASSOCIATION: Institut fiziki AN UkrSSR, Kiev (Physics Institute, AN UkrSSR)

SUBMITTED: 15Dec64 ENCL: 00 SUB CODE: IC

NO REF SOV: 005 OTHER: 002 ATD PRESS: 4051

Card 2/2

MARUSHKO, I.A. [Marushko, I.O.]; MASHKEVICH, V.S. [Mashkevych, V.S.]

Generation of the second optical harmonic in a laser resonator. Ukr. fiz. zhur. 10 no.3:312-322 Mr '65.

(MIRA 18:6)

1. Institut fiziki AN UkrSSR, Kiyev.

L 2312-66 EWA(k)/FBD/EWT(1)/EEC(k)-2/T/EWP(k)/EWA(m)-2/EWA(h)
SCTB/IJP(c) WG
ACCESSION NR: AP5026129 UR/0185/65/010/009/0991/1006

AUTHOR: Buryakovs'kyy, O. Yu. (Buryakovskiy, O. Yu.); Mashkevych, V. S. (Mashkevich, V. S.) 44 44 55 B

TITLE: Theory of stationary radiation of a homogeneous system in a resonator with many modes. II. Optimum conditions for laser emission

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 9, 1965, 991-1006

TOPIC TAGS: resonator, resonator Q factor, vibration theory, laser, laser emission, laser pumping, laser radiation 25,44

ABSTRACT: Conditions for maximum laser emission, i.e., the radiation of special modes above the threshold region, were investigated. The dependence of radiation intensity of resonator modes on pumping was used to determine these optimum conditions. The optimum value for each basic parameter (the transparency of resonator mirrors and the concentration of active centers), on which depends the intensity of radiation of resonator modes at a fixed pumping, was determined individually. The dependence of the number of quanta Q^0 emitted by all special modes in the region above the threshold on the total losses of a special mode a^0 at fixed values of the fringe losses of special mode a^0_{fr} and all other parameters leads to the following

Card 1/2

L 2312-66

ACCESSION NR: AP5024129

2

results: In the investigated range of a^0 values, the function $Q^0(a^0)$ has only one extremum, which is a maximum. The optimum value of a^0 corresponding to this maximum can be found for small values of pumping utilization factor p and sufficiently large pumping. In case of p close to unity and large pumping, the optimum value of a^0 can be obtained explicitly. If the fringe losses are sufficiently small, then with their rise the optimum values of useful losses strongly increase. If the total losses are close to their own maximum value, conditioned by the activity of the special mode, then when the fringe losses increase, the optimum value of the useful losses decreases, so that the total losses increase slightly. With the increase of the number of active centers the optimum value of the useful losses increases. In case of a weak absorption when p is not to close to unity, approximate solutions for two limiting cases of pumping—close to the threshold and considerably exceeding the threshold—were obtained. The dependence of the threshold value of pumping on the concentration of active centers has one extremum, which is a minimum. An analytical solution was obtained for an ideal three-level system for the case of weak absorption and p not close to unity. Orig. art. has: 75 formulas and 4 figures. [JA]

ASSOCIATION: Instytut fizyky AN URSR, Kiev (Physics Institute AN URSR)

SUBMITTED: [illegible]
ENCL: 00
SUB CODE: EC
NO REF SOV: 004
OTHER: 001
ATD PRESS: 4115

Card 2/2

L [illegible]-66 EWT(1)/T IJP(c)

ACC NR: AP6007798 SOURCE CODE: UR/0185/66/011/002/0183/0193

AUTHOR: Marusenko, I. O. (Marusenko, I. A.); Mashkevich, V. S. 36

ORG: Physics Institute AN UkrSSR, Kiev (Instytut fizyky AN URSR) B

TITLE: Proof of the applicability of the method of kinetic equations to the theory of generation of optical second harmonics

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 11, no. 2, 1966, 183-193

TOPIC TAGS: kinetic equation, harmonic oscillation, frequency doubling, laser optics, optic density

ABSTRACT: The authors derive the kinetic equations employed by them earlier (Ukr. fizychn. zh. v. 9, 1146, 1964; Opt. i spektr. v. 20, no. 1, 1966) to determine the intensity of optical harmonics from the equations for the density matrix. The problem is solved for a stationary laser generation mode, the field of the laser beam and the field of the harmonic being expanded in terms of exact normal modes of the electromagnetic field. The system analyzed consists of active centers, fundamental-frequency normal modes, and second-harmonic normal modes. Each center can have three states. The calculations show that the kinetic equations can be derived with account taken of only the first nonvanishing perturbation-theory approximation, and that the off-diagonal elements of the density matrix can be expressed in terms

2

Card 1/2

L 18890-66

ACC NR: AP6007798

of the diagonal case, so that the required frequency summation can be effected. The validity of the derivation is based on two premises, the possibility of neglecting higher perturbation-theory terms and the possibility of splitting the diagonal elements of the density matrix into products of single-particle diagonal matrix elements. Orig. art. has: 17 formulas. [02]

SUB CODE: 20/ SUBM DATE: 03Jan65/ ORIG REF: 004/ OTH REF: 002
ATD PRESS: 4217

Card 2/2 mc

MARUSHKO, I.A.; MASHKEVICH, V.S.

Line width of induced Raman scattering. Opt. i spektr. 19 no.1:136-138 Jl '65. (MIRA 18:8)

L 27733-66 EWT(1)/EWP(e)/EWT(m)/T IJP(c) GD/WH

ACC NR: AT6015129 SOURCE CODE: UR/0000/66/000/000/0003/0012

AUTHOR: Strizhevskiy, V. L.

46
B+1

ORG: Institute of Physics AN UkrSSR (Institut fiziki AN UkrSSR)

TITLE: Nonlinear optical effects and spatial dispersion in crystals

SOURCE: Respublikanskaya shkola po kvantovoy elektronike. Kvantovaya elektronika (Quantum electronics); trudy seminara. Kiev, Naukova dumka, 1966, 3-12

TOPIC TAGS: light dispersion, nonlinear effect, laser optics, crystal theory, exciton absorption, perturbation theory

ABSTRACT: The author considers frequency addition as a basis for explaining the effect which spatial dispersion of nonlocalized excitations has on nonlinear optic effects in crystals. An expression is derived within the framework of perturbation theory for the probability amplitude of the three-photon process with resonance in intermediate states, and the case where exciton states are intermediate is considered. The proposed theory is applied to addition of focused and plane waves and possible influence of spatial dispersion are studied. The fundamental requirement for experimental observation of this effect is laser emission with a frequency lying within the the region of exciton absorption for the crystal. The outstanding possibility for producing the required frequencies is the ruby laser which produces radiation in the ex-

Card 1/2

L 27733-66

ACC NR: AT6015129

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citon absorption region of CdSe. There are two principle difficulties involved in detection of these effects for the case of focused fields: the requirements for precise focusing and the intense heat release which raises the temperature and thus reduces the free path of the exciton. However, addition of waves in regions which do not overlap could be direct proof of spatial dispersion. The relationship between spatial dispersion and crystal thickness may be used as a criterion for the existence of the effect in the case of plane wave addition. Orig. art. has: 20 formulas. [14]

SUB CODE: 20/ SUBM DATE: 12Feb66/ ORIG REF: 004/ OTH REF: 002/
ATD PRESS: 5002

Card 2/2

L 20422-66 FBD/EWT(1)/EEC(k)/T/EWP(k)/EWA(h) IJP(c) WG

ACC NR: AP6004412 SOURCE CODE: UR/0051/66/020/001/0117/0127

51

B

AUTHOR: Marushko, I. A.; Mashkevich, V. S.

ORG: none

TITLE: A method of kinetic equations in the theory of second-harmonic generation

SOURCE: Optika i spektroskopiya, v. 20, no. 1, 1966, 117-127

TOPIC TAGS: laser, nonlinear optics, second harmonic, harmonic generation, spectral line, line broadening

ABSTRACT: A theoretical study is made of second-harmonic generation in a stationary regime by a laser beam of finite spectral width. The method of kinetic equations used was developed by the author (Ukrainskiy fizichnyy zhurnal, v. 8, 1963, p. 918, and v. 9, 1964, p. 226) and is based on quantum mechanical considerations. The spectral line is represented by a set of monochromatic lines corresponding to exact normal oscillations of the electromagnetic field distributed with a certain density. General expressions for the total probability of second-harmonic generation are used in deriving an expression for the angular distribution of intensity of the second harmonic in reflected and transmitted rays. It is shown that the dependence of the intensity of the second harmonic on the angle of incidence will be oscillatory. In the case of normal incidence, the line shape of the second harmonic is expressed by an integral equation which is solved for the cases when the shape of the pump line is

Card 1/2

UDC: 621.375.9.535.001.1

L 20422-66

ACC NR: AP6004412

either Gaussian or Lorentzian. It is shown that generation of a harmonic usually results in broadening of the fundamental. When the pump line is Gaussian, the second harmonic exhibits a tendency for narrowing. Orig. art. has: 22 formulas and 2 figures. [CS]

SUB CODE: 20/ SUBM DATE: 10Sep64/ ORIG REF: 008/ OTH REF: 005/ ATD PRESS: 4232

Card 2/2

L 32632-66 FBD/EWT(1)/EEC(k)-2/T/EWP(k) IJP(c) WG/WW/GG

ACC NR: AP6018820 SOURCE CODE: UR/0056/66/050/005/1410/1414

AUTHOR: Mashkevich, V. S.; Vinetskiy, V. L.

79
B

ORG: Institute of Physics, Academy of Sciences Ukrainian SSR (Institut fiziki Akademii nauk Ukrainskoy SSR)

TITLE: Role of light absorption by free carriers in a semiconductor laser

SOURCE: Zh eksper i teor fiz, v. 50, no. 5, 1966, 1410-1414

TOPIC TAGS: light absorption, [redacted], charge carrier, semiconductor laser, carrier density, laser emission, photon, exciton, laser pumping

ABSTRACT: The authors present a consistent analysis of the interaction between radiation and the medium in a semiconductor laser whose characteristic parameters without allowance for absorption by free carriers were determined by them earlier (FTT, v. 6, 2037, 1964). It is shown that when absorption of photons by the free carriers is taken into account, the kinetic equation for the radiation-medium system can have three solutions corresponding to different carrier densities. Only two are stable and only one of these gives stable laser emission. The analysis is restricted to the simplest case of interband transitions in an impurity-free semiconductor, neglecting the binding between the carriers and the excitons, although the latter assumption turns out to be in disagreement with the actual physical situation. The stable laser solution is obtained in the case of weak absorption by the free carriers, and a criterion for the realizability of this solution is derived The threshold pump ener-

Card 1/2

L 32632-66

ACC NR: AP6018820

gies of the different solutions are found. The second stable solution, which does not correspond to a laser mode, and the unstable laser solution, occur when the carrier density is high, so that the screening of the electron-hole gas becomes appreciable. The results indicate that when attempts are made to obtain laser action in a semiconductor by applying excessive pump power, there is the danger of producing conditions corresponding to one of the additional solutions. This is borne out by some recently published data (G. Burns and M. J. Nathan, Proc. IEEE, 52, 822, 1964). Orig. art. has: 1 figure and 20 formulas. [02]

SUB CODE: 20/ SUBM DATE: 07Dec65/ ORIG REF: 007/ OTH REF: 002/ ATD PRESS: 5025

Card 2/2

L 45861-66 EWT(1)/EEC(k)-2/T/EWP(k) IJP(c) WG/GD

ACC NR: AT6015142 SOURCE CODE: UR/0000/66/000/000/0214/0227

AUTHOR: Vinetskiy, V. L.; Kolychev, N. N.; Mashkevich, V. S. 78

ORG: Institute of Physics, AN UkrSSR (Institut fiziki AN UkrSSR); Institute of Semiconductors, AN UkrSSR (Institut poluprovodnikov AN UkrSSR) B+1

TITLE: Theory of laser radiation from impurity-band transitions 25

SOURCE: Respublikanskiy seminar po kvantovoy elektronike. Kvantovaya elektronika (Quantum electronics); trudy seminara. Kiev, Naukova dumka, 1966, 214-227

TOPIC TAGS: laser, solid state laser, semiconductor laser, laser theory, LASER RADIATION, IMPURITY BAND

ABSTRACT: The semiconductor laser operation based on radiative transitions of current carriers from impurity-band state to bound state is examined by the method of kinetic equations. A semiconductor having M identical impurity centers with a level in the forbidden band is considered. Pumping drives the electrons from the valence band into the conduction band. Electron-hole recombination takes place at M levels. Hole capture by an impurity level is accompanied by radiation of a photon. Kinetic equations and a neutral-condition equation are set up. Solutions for the case

Card 1/2

L 15801-66

ACC NR: AT6015142

of acceptor and donor centers (Boltzmann distribution and strong degeneration in the hole band) are given. Absorption by free carriers is allowed for. This special feature of the impurity-band laser is noted: In some cases (medium pumping), populations of m, p, n levels and generated frequency vary when pumping produces a higher-than-threshold number of electrons (holes) Φ ; the number of quanta radiated by the special mode per unit time increases with pumping in a slower-than-linear manner; this deviation from linearity is pronounced with Φ approaching Φ_{thresh} (m is the number of electrons at impurity levels; p is the number of holes in the valence band; n is the number of electrons in the conduction band). This feature is due to the absence of thermal equilibrium between the impurity and the band. Orig. art. has: 2 figures, 80 formulas, and 2 tables.

SUB CODE: 20 / SUBM DATE: 12Feb66 / ORIG REF: 006 / OTH REF: 001

Card 2/2 ULR

L 01059-67 EWT(1)/T IJP(c) GD

ACC NR: AT6015131 SOURCE CODE: UR/0000/66/000/000/0034/0076

AUTHOR: Mirushko, I. A.; Mashkevich, V. S.

51
B+1

ORG: Institute of Physics, AN UkrSSR (Institut fiziki AN UkrSSR)

TITLE: Method of kinetic equations in the theory of generation of optic harmonics

SOURCE: Respublikanskiy seminar po kvantovoy elektronike. Kvantovaya elektronika (Quantum electronics); trudy seminara. Kiev, Naukova dumka, 1966, 34-76

TOPIC TAGS: laser theory, solid state laser, kinetic equation

ABSTRACT: 1. Deduction of kinetic equations from a density-matrix equation for the case of generation of the second optical harmonic. Only stationary conditions of generation and only the process of frequency summation are considered. The analysis is made in the first nonvanishing approximation of the disturbance theory; contribution of multiphoton processes is neglected. The kinetic equations are:

$$\dot{\bar{q}}_1^l = \frac{2\pi}{\hbar} B \sum_{j,k} \left[\bar{q}_2^j (\bar{q}_1^l + 1)(\bar{q}_1^k + 1) - (\bar{q}_2^j + 1)\bar{q}_1^l \bar{q}_1^k\right] \delta(E_l + E_k - E_j) - \alpha_1^l \bar{q}_1^l + N^l.$$

$$\dot{\bar{q}}_2^j = \frac{\pi}{\hbar} B \sum_{l,k}^{l \neq k} [(\bar{q}_2^j + 1)\bar{q}_1^l \bar{q}_1^k - \bar{q}_2^j (\bar{q}_1^l + 1)(\bar{q}_1^k + 1)]\, \delta(E_l + E_k - E_j) - \alpha_2^j \bar{q}_2^j.$$

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Applicability of these equations to near-stationary conditions of generation is briefly discussed. 2. Generation of the second harmonic in a plane-parallel slab. It is clarified which field vector potential should be used for calculating the nonlinearity B in the above kinetic equations. In each particular case of solving the kinetic equations, construction of orthonormalized solutions of the Maxwell linear equations is required. Kinetic equations and total-quanta-number equations for the second-harmonic generation in the slab are derived. From them, this formula for efficiency is derived: $k=\frac{a_0(\varepsilon_2^R+\varepsilon_2^T)}{N\hbar\omega_1}=\frac{2a_0(q_2^R+q_2^T)}{N}$. The second-harmonic intensity in the transmitted and reflected light dependent on the angle of incidence (formula given) is convenient for determining the degree of agreement between the calculated and observed data. 3. Line shape in the second-harmonic generation with a specified pumping at fundamental frequency. The above generation case is also used for investigating the line shape. An integral equation describing the time shape is solvable only in two particular cases: (A) Gaussian curve (weak and strong generation regions); and (B) Lorentzian curve (weak generation). 4. Second-harmonic generation in the laser resonator. The harmonic generation depends on the nonlinearity $\bar{B}$, photon density q_1 in the beam, and the loss ratio at fundamental and harmonic frequencies. Hence, an efficient harmonic generation can be achieved by

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placing the nonlinear crystal into the laser resonator. The generation efficiency is equal to a ratio of the harmonic power to the dominant-mode-plus-harmonic power: $k=\frac{\alpha_2 2\hbar\omega_1 q_2}{\alpha_1\hbar\omega_1 q_1+\alpha_2 2\hbar\omega_1 q_2}=\frac{2\alpha_2 q_2}{\alpha_1 q_1+2\alpha_2 q_2}=\frac{2\alpha_2\bar{B}q_1}{2\bar{B}q_1(\alpha_1+\alpha_2)+\alpha_1\alpha_2}$. To find the effect of laser pumping on the harmonic efficiency, the dominant-mode equation is solved for these cases: (A) The near above-threshold pumping region for which this condition holds true: $|\alpha_2\mathring{B}_2(m_1-n^{11})-2\bar{B}B_e n^{11}|^2\gg 8\bar{B}B_2 B_e n^{11}\alpha_2(m_2-n^{11})$; (B) The pumping region in which this condition is satisfied: $|\alpha_2\mathring{B}_2(m_1-n^{11})-2\bar{B}B_e n^{11}|^2\ll 8\mathring{B}_2 B_e n^{11}\alpha_2(m_2-n^{11})$. (C) The strong pumping region with this condition satisfied: $|\alpha_2\mathring{B}_2(m_1-n^{11})-2\bar{B}B_e n^{11}|^2\gg 8\bar{B}B_e n^{11}\alpha_2(m_1-n^{11})$, $m_1-n^{11}<0$.

5. Generation of the third optical harmonic. The kinetic equations, the law of conservation of the number of quanta, the line shape, and the efficiency of third-harmonic generation are discussed. Orig. art. has: 2 figures and 210 formulas.

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Mashkevich, Vladimir Stefanovich

Principles of the kinetics of laser radiation (Osnovy kinetiki izlucheniya lazerov) Kiev, Naukova dumka, 1966, 234 p. illus., biblio. (At head of title: Akademiya nauk Ukrainskoy SSR. Institut fiziki) 4,600 copies printed.

TOPIC TAGS: quantum mechanics, laser theory, laser radiation, kinetic equation, luminescence center, semiconductor laser, optic dispersion

PURPOSE AND COVERAGE: This book views a series of questions on the theory of lasers based on the method of kinetic equations. A detailed study is made of the stationary generation of laser radiation in transitions in luminescent centers, in various transitions in semiconductors and in combination scattering. The problem of stability of stationary conditions is analysed, and the theory of gigantic pulses is given. This book is recommended for scientists and students in advanced courses of university level physics departments.

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